SCRIPPS RESEARCH OVERVIEW

THE OCEANS AND GLOBAL CHANGE

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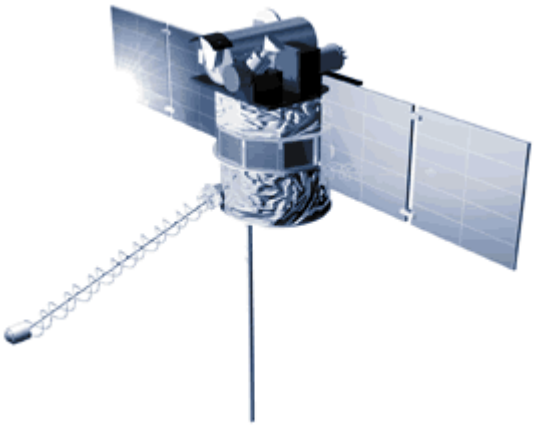
Monitoring the Climate from Deep Space



Scripps is participating in the Deep Space Climate Observatory (DSCOVR) satellite mission, which will collect key information about Earth's climate system using the first deep-space climate satellite.

With new scientific instruments taking a broad set of measurements, the spacecraft will have a continuous view of the sunlit side of Earth from a vantage point 1.5 million kilometers away. DSCOVR's measurements of infrared radiation emitted by Earth will be used to monitor global warming and climate variability. Measurements of the solar wind, magnetic fields, and plasma will advance research and provide early warning of solar events that may pose threats to Earth satellites. DSCOVR's views of the details of Earth's atmosphere and surface will be distributed to schools and the general public via the Internet.

Early Warning of Carbon Dioxide Buildup

A Scripps marine chemist was the first scientist to confirm the buildup of carbon dioxide in the atmosphere. His precise measurements of atmospheric gases produced a data set now known widely as the "Keeling Curve."

Before Dr. Charles David Keeling's investigations, scientists did not know the fate of the excess carbon dioxide in the atmosphere that is produced by the burning of fossil fuels and other industrial activities. Keeling's research, however, has shown that atmospheric carbon dioxide levels are increasing. They have risen more than 14 percent since 1957.

Analyzing the Role of Aerosols in Global Climate

Scientists participating in the international Indian Ocean Experiment (INDOEX) have determined that dense pollution produced in Asia and the Indian subcontinent is significantly disrupting the natural atmosphere over the Indian Ocean, raising serious environmental questions.

The new evidence also suggests that rather than being an isolated concern the extensive pollution may have global implications. The $25 million project, which involves more than 150 scientists internationally, has shown that a dark haze layer of tiny particles called aerosols is responsible for a three-fold reduction in sunlight reaching Earth's surface. The project is coordinated by the Center for Clouds, Chemistry and Climate (C4) at Scripps. Aerosols, particles about a millionth of a centimeter in diameter, consist of sulfates, soot, organic carbon, and mineral dust. They are produced both naturally and by human activities.

Abrupt Climate Change
Using a new technique to analyze air trapped in ancient ice cores, scientists at Scripps and Washington State University determined that the end of the last ice age was triggered by an abrupt period of warming.

The researchers found that temperatures in Greenland rose by 16 degrees Fahrenheit in less than two decades, bringing the last ice age to a close about 15,000 years ago. Their work supports recent findings that the end of the ice age was triggered by an abrupt period of warming, rather than gradual warming over thousands of years as previously believed. Understanding what triggers abrupt climate events may help researchers improve computer models used to predict global warming. It may also help decipher the effects on future climate of carbon dioxide from burning fossil fuels entering the atmosphere.

Profiling the Global Ocean
Launched in 2000, the Argo program is now deploying a global array of 3,000 floats to gather subsurface ocean data to improve understanding of the climate system and climate change.

Mariners have long studied surface currents, but only by using expensive shipborne equipment to record ocean properties such as temperature and salinity have they been able to analyze deep-ocean currents. The Sounding Oceanographic Lagrangian Observer (SOLO), developed by Scripps scientists, is a float that drifts with the currents at depths down to 2,000 meters. Using SOLO and similar instruments, the Argo floats drift beneath the surface at a specified depth for a period of 10 days. The floats then rise to the surface, collecting a vertical profile of temperature and salinity data that is immediately transmitted via satellite to an Argo Data Center. The floats return to their assigned depth and continue making measurements for a lifetime of three to five years, surfacing on a regular basis to report.

Global Ocean Observation
The Partnership for Observation of the Global Oceans (POGO), composed of Scripps and other major international oceanographic institutions, will work with others in the ocean, earth, and atmospheric science communities to promote global oceanography.

POGO's goal is to further the implementation of an international and integrated global ocean observing system. This partnership includes institutions performing oceanographic observations, operating ships, building sensors, collecting and processing data, conducting scientific research, and in some cases, providing operational services to the ocean and earth science communities. As the scale of these activities has become more global, the value of coordinating international programs has increased. Through joint planning and exchange of information, the oceanographic community makes better use of the limited resources available from governments and other sources for ocean observations.

Detecting Global Warming with Sound
Scripps scientists are leaders in detecting warning signals of possible global warming.

In the North Pacific Acoustic Laboratory (NPAL) project, scientists are studying the behavior of sound transmissions in the ocean over long distances. NPAL, formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) project, is the continuation of a Scripps-led international research initiative to use sound waves in the sea to determine how ocean temperatures are changing. Because sound travels faster in warmer water, the scientists have been able to monitor changes in ocean temperature by taking repeated measurements over time. As part of the project, scientists studied the response of marine mammals to the sound transmissions. After completion of the initial two-year phase of the study, scientists observed no negative impacts on marine life.

Pinpointing Long-Term Ocean Cycles
Scripps scientists have discovered a 1,800-year cycle of oceanic tides that appears to drive changes in Earth's climate.

They have found that strong tides bring cool conditions to the sea surface and drive down temperatures in the air and over land. Weak tides lead to less cold water mixing and warmer periods on Earth. Research at Scripps has shown that Earth is currently in a period in which a natural rise in global temperature-due to the 1,800-year tidal cycle combined with warming from the greenhouse effect-will push the planet through an era of rapid global warming.

Polar Ice Reveals Ancient Climates
Analyses of polar ice cores are providing valuable information about Earth's climate history.

Scientists obtain information about how changes in greenhouse gases and temperature have affected Earth's atmosphere by analyzing trapped air contained in ice layers deposited over hundreds of thousands of years. Recently, Scripps scientists used Antarctic ice cores to reconstruct atmospheric carbon dioxide levels over the last 265,000 years. Such information gives researchers insights into the natural cycle of climate changes the planet is likely to undergo as well as how human activity may trigger future changes in climate.

The World Ocean Circulation Experiment
Scripps researchers are among the founders and key participants in planning and executing the largest scientific program ever attempted in the world's oceans: the World Ocean Circulation Experiment (WOCE).

Scientists from 40 countries conducted intense sea operations from 1990 to 1997 to study world ocean circulation and its interaction with the overlying atmosphere, a relationship not well understood. Analysis and modeling of the data collected will continue until 2007. As part of WOCE, new instruments were developed to determine flow, mixing, and heat-transfer rates. Scripps scientists developed tools to identify the unique chemical "fingerprint" of currents, enabling the researchers to track deep-ocean circulation from pole to pole. Scripps researchers also developed new tools to track subsurface and surface circulation. Combined with data from satellites, data from these

new instruments will help researchers develop better models of how the climate may react to changes such as the buildup of greenhouse gases.

Deep-Ocean Global Circulation
Scripps scientists have developed an autonomous underwater glider, Spray, which cycles vertically between the deep ocean and the surface to communicate with satellites.

Unlike floats that drift with the currents, Spray has wings that allow vertical motion to be converted into forward gliding motion so that the location of measurements can be specified rather than dictated by the currents. Underwater gliders such as Spray will allow scientists to measure the ocean's structure and velocity at a predetermined point or along planned transects without the high cost of operating a research vessel.

El Niño
Scripps scientists were at the forefront of predicting the El Niño event of 1997-98 and the La Niña events of the following two years.

These dramatic warmings/coolings of sea-surface temperatures in the tropical eastern Pacific Ocean sparked changes in climate around the world. Scripps has been a leader in El Niño research for several decades, especially in predicting warm/cold events and their impacts on global climate.

Monitoring Oxygen Levels in the Atmosphere
A Scripps scientist developed the technology needed to monitor minute changes in atmospheric oxygen levels.

This information is critical to understanding Earth's carbon and oxygen cycles and in determining how they are affected by human activities such as burning fossil fuels and deforestation. Only about half of the human-produced carbon dioxide goes into the atmosphere. It is unclear how much of the rest is taken up by land plants and how much is absorbed by the oceans. Studying changes in oxygen levels can help answer this question. Scripps scientists are monitoring changes in oxygen levels at a number of sites around the world.

Communicating Global Climate Change Science
The UC Revelle Program is a collaborative effort to improve communication and enhance the impact of research in the natural and social sciences on policy issues related to global climate change.

Program participants endeavor to identify important scientific research relevant to policy issues and to make this science readily available, in an understandable form, to nonscientific audiences such as policy makers and business leaders. The UC Revelle Program stimulates interaction between researchers in the natural sciences and those in the social sciences and law. This process enables scientists to learn about policy making and how scientific results are taken into account in deliberations. More importantly, it enables scientists to provide policy makers with timely scientific knowledge needed for those deliberations. The program is led by Scripps, the UC Institute on Global Conflict and Cooperation, and the UCSD Graduate School of International Relations and Pacific Studies.

Early Spring
Spring has arrived progressively earlier in parts of the Northern Hemisphere since the mid-1970s, lengthening the growing season about a week, according to research conducted at Scripps.

This finding may be an effect of global warming. After analyzing carbon dioxide measurements taken in Hawaii and in the Arctic, Scripps researchers discovered that seasonal variations in carbon dioxide uptake by Northern Hemisphere land plants have increased significantly since the 1960s, apparently in response to rising temperatures.